MEMORANDUM

CH2MHILL

Draft Response to DTSC Comments on Draft Remedial Investigation Report Omega Chemical Superfund Site Operable Unit 2

TO: Christopher Lichens/USEPA Region IX

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DATE: April 29, 2008

Background

As United States Environmental Protection Agency (EPA) requested, CH2M HILL submitted the *Draft Remedial Investigation Report Omega Chemical Superfund Site Operable Unit 2*, dated January 2008, to the California Department of Toxic Substances Control (DTSC) on February 13, 2008 for technical review. DTSC provided written comments to EPA and CH2M HILL on April 1, 2008 in a letter dated March 24, 2008.

We have found no significant differences between the DTSC and CH2M HILL interpretation of the site stratigraphy and hydrogeology. The majority of DTSC's comments on the hydrogeology and stratigraphy appear to have resulted from the reviewer's mistaking the Regional Hydrogeology (Section 4.5.1) for the Site Hydrogeology (Section 4.5.2). Section 4.5.1 presents an overview of the hydrogeology of the basin based on literature review, while the interpretation of the site hydrogeology based on the investigation results is presented in Section 4.5.2. The report will be revised to make this distinction more clear.

The comments on the Omega model mostly address the assignment of the boundaries and volumetric budget. The model volumetric budget (attached) will be added to the report; the budget shows that the model does not have any of the problems the comments imply. The text will be revised to avoid any misunderstanding of the model boundaries.

Many of the comments do not provide specific recommendations on revisions to the report or other corrective actions. EPA sent a clarification request (prepared by CH2M HILL, dated April 2, 2008) to DTSC on April 3, 2008. DTSC provided limited clarification on April 4, 2008.

The DTSC comments were separated into paragraphs, as appropriate, to better address separate issues raised within one comment. The responses also provide specific recommendations on revisions to the report to address the comments.

Comment #	Comments from DTSC	CH2M HILL Responses
1	The report states that the Gaspur aquifer is present beneath the site, but the boring logs do not support this conclusion. The Gaspur aquifer locally consists of Recent deposits of the San Gabriel/Rio Hondo system, and is characterized by a basal unit of cobble-to-boulder river channel deposits. Materials matching descriptions of this unit are not found in boring logs beneath the site. Bulletin 104's description of the Santa Fe Springs Plain seems more apt. The alluvial fans just east of the site show obvious evidence of structural warping and abandoned terraces consistent with continuing uplift and tilting along the Repetto Hills. One example is capture of a portion of the Worsham Canyon alluvial fan by the Turnbull Canyon fan, with subsequent rebuilding the Worsham fan southeast of its former course. The broad regional descriptions in Bulletin 104 need to be re-referenced with respect to local geomorphic features.	The comment statement "The report states that the Gaspur aquifer is present beneath the site, ..." is not correct. The report does not make a conclusion that the Gaspur aquifer is present at OU2. Section 4.5.1 appropriately mentions Gaspur in the discussion of regional hydrogeology, Section 4.5.2 (OU1 and OU2 hydrogeology) does not. Section 4.5.2.7 cites stratigraphic interpretation from other reports with a qualifying assessment; the report does not accept these earlier stratigraphic interpretations. Bulletin 104 shows Gaspur deposits at the location of MW21 and along the western margin of OU2. Coarse sands with granitic and metamorphic clast were found at MW21 and MW22; these sediments are interpreted to be fluvial deposits with gravel material that originated in the San Gabriel Mountains. These deposits likely correlate with the Gaspur Aquifer. The transition from alluvial to fluvial deposits occurs just outside of the western limit of OU2 in the area of MW21 and MW22. This discussion will be added to Section 4. The alluvial fans northeast of the Omega property originated from the Puente Hills, not from the Repetto Hills (Please see also the response to Comment 6). Discussion of the alluvial fans associated with the Worsham and Turnbull Canyons will be added to Section 4 and local geomorphic features will be shown on a topographic map.
2	Section P-P' and Plate 7 of Bulletin 104 show that the site is actually on a physiographic terrace about ten feet above the main deposits of the San Gabriel River. The site is not on the river's current floodplain, and it is not clear whether flooding by the river was involved in cutting Sorensen Drain. The Gaspur aquifer is defined as San Gabriel/Los Angeles River channel deposits, which are typically very coarse-grained with boulders being present as far as south Downey. These deposits are not present under the site, nor are they shown as present in Bulletin 104. This distinction is important, because, in the absence of large pumping effects, the depositional direction of the sediment largely controls contaminant migration pathways. The topographic map shows that the site is mainly on a physiographic alluvial fan, which is composed of a complex overlapping of fans originating in Turnbull and Worsham canyons, and extending around the Santa Fe Springs Anticline out	Section P-P' and Plate 7 of Bulletin 104 show areas northwest from OU2 (Whittier Narrows and the area southwest of them, respectively), neither of them extends onto "the site." It is not clear from the comments (e.g., Comment 3) whether the term "site" means the former Omega Chemical, Inc. property or OU2 (a clarification was requested on April 3, 2008). The term "site" was not used in the report to avoid potential ambiguity and instead the text adopts the terms "Omega property" or "OU2", as appropriate; the scope of the investigation covered the entire OU2. The April 3, 2008 letter requested clarification of the term "site" used in the different comments. Section 4 will be revised to explicitly state that the Gaspur Aquifer has not been identified at OU2 but it is present along its western

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	towards the coastal plain. There is no San Pedro formation beneath the site according to Bulletin 104.	margin. Please see also our response to Comment 1. This is not correct. Bulletin 104 states that the San Pedro formation underlies the entire Whittier Area (page 163) and that it is exposed on the south side of the Puente Hills (page 165). Bulletin 104 shows San Pedro formation beneath the entire OU2 with overlying Lakewood and recent deposits (e.g., sections B and N of the Bulletin). The known extent of the OU2 contamination is limited to the deposits overlying the San Pedro formation.
3	Section 4.5.1.4. The groundwater flow discussion is incomplete. Groundwater in the channel deposits of the San Gabriel River flow generally down channel, but groundwater within the alluvial fans originating in the Puente Hills flows down the depositional axes of the fan deposits. This can be demonstrated by drawing the plume to scale on the topo map. The plume flows at right angles to the contours, directly beneath and parallel to the surface expression of the Turnbull/Worsham fan. Downgradient of the site, the fans merge into the Gaspur, and the plume direction changes to become parallel with the River, although it does not merge into the River.	Discussion of the alluvial fans associated with the Worsham and Turnbull Canyons, and a topographic map with surface elevation contours and major features will be added to Section 4.
4	Further support to the idea that these are alluvial fans is the observation that the groundwater gradient flattens just above the approximate location of the topographic transition from the midfan segment to the distal fan segment, which is where permeability normally drops an order of magnitude. The curvature in the groundwater contours by Los Nietos Rd may be related to water coming down the Worsham fan.	It is expected that the distal portion of the fan complex will contain finer-grained and less permeable material than the portion near the mountain front. However, the lithology of the unconfined aquifer zone and the aquifer test results do not indicate such a trend. Medium to coarse sands were found in the unconfined zone throughout OU2, indicating that the fans are dissected by channels.
5	Section 4.5.2.3 Lithology. The materials beneath the site are not consistent with the clean, coarse deposits of the San Gabriel River. They are thin, discontinuous, and mainly fine-grained, with only occasional gravels. It is significant that the only boring log including the word 'cobble' occurs near the apex of the fan, and sediments become finer, not coarser, downhill of this well. This is not what would be expected of deposition by the San Gabriel River, even allowing for deformation. (*DTSC clarified that the boring log with the word "cobble" was for*	Discussion of San Gabriel River deposits does not appear in this section. The basis for this comment is not clear. This section describes the color, weathering, and grain size of the soils found at OU2, and classifies them as continental deposits. The text mentions the possibility of fossil soil horizons which would be consistent with alluvial fan deposition.

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6	Section 4.5.2.5 Another plausible interpretation of the stratigraphic data is that the site is underlain by Lakewood-equivalent alluvial fan deposits originating in the Repetto Hills from specific, geographically restricted fans. The apparent stacking of sediments, the many discontinuities perpendicular to the fan (see Section B-B') and the fewer longitudinal discontinuities are explained as a natural consequence of typical alluvial fan sedimentation. There is obvious topographic evidence of continuing deformation of the fans during the later Pleistocene and Holocene. However, it is clear that the fans have continued to maintain their integrity despite deformation.	Repetto Hills are located about 10 miles northwest of the former Omega property and about 9 miles northwest of Whittier Narrows. Because the piedmont slope is generally to the southwest in Whittier and Los Angeles, it seems unlikely that the deposits found at OU2 have originated in the Repetto Hills. The sediments eroded from the Repetto Hills would have to cross the San Gabriel River in order to be deposited at OU2. The Puente Hills are considered to be the source area for most of the material in the shallow sediments at OU2. The report will be revised to say that the depositional environments included alluvial fans. The following section (Section 4.5.2.6) states that the OU2 sediments likely represent a transition of an alluvial fan into a floodplain. The text will also state that although the deeper units (likely time-equivalent to the San Pedro formation) may transition into marine facies, the presence of marine deposits could not be inferred from the investigation data. The report discusses the folding deformations and is consistent with the comment.
7	Section 4.5.2.6 Conceptual Hydrogeology. The actual site hydrogeology does not match the regional hydrogeology as presented in the preceding sections. The principal difference is in the assumed direction of the depositional axis of the sediment. There are two possibilities: if the entire thickness of sediments originated as fluvial deposits of the San Gabriel River, a north-south section, parallel to the river, would show more continuity of deposits than the with the transverse section, which would show the ends of channels and poor horizontal correlations. If the sediments were deposited by alluvial fans, they would show an east-west longitudinal continuity pattern, with poorer continuity along north- transverse sections. The cross sections favor the alluvial fan interpretation. Sections A-A' and C-C' could readily be reinterpreted as longitudinal sections along a fan, with an upper and lower zone, in continuity near the apex of the fan, which is also the locus of recharge to the deeper zones, and Section B-B' appears more typical of a transverse section of a fan.	Concur. The OU2 hydrogeology, as interpreted from the site investigation results, is somewhat different from the interpretation in Bulletin 104 upon which the discussion of the regional hydrogeology (Section 4.5.1) is based. The report does not discuss a "depositional axis of the sediment," neither does it state that the deposits originated as fluvial deposits of the San Gabriel River (that is not the interpretation). We concur that the cross-sections support the interpretation of alluvial depositional environment. The report will be revised by adding a discussion of the better correlation of lithologic units along Sections A and C relative to Section B, which is supportive of the sediments being part of an alluvial fan. The head differences measured in cluster wells near the Omega

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	The idea that this is a simple alluvial fan sequence makes it easier to understand how contamination reached the deeper zone, specifically, because near the apex of a fan, there is vertical continuity between the upper and lower sediments.	property (on Putnam Street) are greater than 10 feet, indicating significant hydraulic separation of the screened units. This area is the closest to the "apex of the fan" yet the hydraulic continuity does not appear to exist. On the contrary, the vertical head differences observed just southwest of the Omega property explain the downward contaminant migration into the unit atop SB5 where the plume was intercepted by MW23C. The apexes of the fans, composed of coarse sediments with vertical hydraulic head continuity, are farther northeast from the Omega property, close to the foothills of the Puente Hills. This discussion will be added to the report.
	The report's interpretation must invoke some other type of connection between the upper and lower zones to produce the observed pattern of contamination, yet is silent on how the vertical contamination occurred.	The discussion of the contamination pathway into the deeper zone will be expanded. The vertical communication is discussed in Section 4.5.2.6. As seen in Section B, the lateral continuity of lithologic units is limited in the direction roughly perpendicular to the groundwater flow. The vertical hydraulic separation is not expected to be uniformly present across OU2; locally, where fine-grained units terminate, contaminated groundwater may flow downward into deeper zones (Section 4.5.2.6). The fine-grained units underlying the shallow, contaminated groundwater zone shown on Sections A and C may terminate northwest or southeast of the sections. Well MW24 was installed to intercept the pathway from the unconfined aquifer zone into the unit atop SB5; however, the aquitards are contiguous at this location indicating that the pathway exists outside of Section A. The groundwater flow in the deeper sand zone (screened by OW4B and OW8B) is slightly more to the south than in the unconfined zone, indicating that the contaminant pathway is likely southeast of Section A. Section 6 will be expanded to include the discussion of potential contaminant pathways from the unconfined aquifer zone into deeper units (the discussion of the extent of contamination is presented in Section 5, and the site conceptual model is presented in Section 6; Section 4 does not discuss the extent of contamination or contaminant pathways).
8	Vertical gradients are not discussed in this section, but there are some very troubling trends. At MW-25 A-B-C-D, there is a downward gradient that directly conflicts with the interpretation that the anticline forces water to move upward over its crest. Instead,	The report does not present "the interpretation that the anticline forces water to move upward over its crest." The second paragraph on page 4-11 explains the steepening of the shallow

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	there is a very strong downward gradient, and no obvious way to prevent downward migration of the water in the lowest zone of MW-23. In fact, it is not clear at all where the water in MW23-C goes next, because MW-25D is not directly structurally downgradient of MW-23C. Contouring head on the cross sections might suggest some interesting flow patterns that have not been addressed in the RI.	groundwater gradient across the northeastern limb of the anticline. Downward gradients, or more accurately piezometric heads decreasing with the depth of the screened unit, were observed over most of OU2. The main reason for this condition is attributed to the production pumping from deeper aquifer units in the basin, and the recharge to the spreading grounds and along the southwest front of the Puente Hills. Groundwater flow in the basin is dominated by recharge to the spreading basins and production pumping; the recharge to the shallow subsurface and pumping from depths generally greater than 200 feet create downward gradients. The contamination found at MW23C may be laterally limited, but it may also extend to production well 2S/11W-30R3. Depth-discrete sampling and flow logging of the production well showed that groundwater near the top of its screen contains about 5 μg/L of PCE. Contamination in this deeper zone will be addressed under an upcoming Feasibility Study. A discussion will be added to Sections 5 and 6. Head contours will not be added to the sections because the contours cannot be unambiguously drawn. There are likely head discontinuities across some of the fine-grained units, further complicating any head contouring effort.
9	Section 4.5.3 Aquifer Properties GSU disagrees with the practice of separating out the more conductive zones of the aquifer, and assigning hydraulic conductivity to just that zone. This practice will tend to vastly underestimate the practical transmissivity of the aquifer, and lead to overestimating hydraulic parameters during modeling. Aquifers act as a unit, and dewatering a thin zone of high conductivity may also involve dewatering, by leakance, a much thicker zone of lower conductivity. A more conservative practice would be to calculate a geometric average of the Ks of the entire aquifer thickness. A unit that appears as a barrier during a short-term test may be a significant source of flow over tens of years. Lateral facies changes produce horizontal anisotropy, with its	The monitoring wells were screened across the coarser, more permeable units and the aquifer tests conducted were relatively short-term (slug tests; pumping tests in a duration of few hours). As a result, the tested aquifer zones were not dewatered and leakage across the fine-grained units was minimized during the testing (this is especially true for the slug tests). The aquifer properties estimated from the tests are characteristic of the coarser units. The coarse-grained and fine-grained units were explicitly represented in the numerical model. This approach is more appropriate for a solute transport model than the suggested use of a "geometric average of the Ks of the entire aquifer thickness." The use of geometric mean hydraulic conductivity would actually lead to *under*estimation of solute transport velocities by the model.

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	principal axis parallel with deposition, and its minor axis perpendicular to the axis of deposition. This effect, if not sought during aquifer tests, mimics leakance, and leads to overestimating K. The net effect is that the method described is likely to overestimate K, and underestimate downgradient capture radii.	The majority of the aquifer tests conducted at OU2 were single-well tests (all except the pumping test at EW1); hydraulic conductivity estimates from single-well tests are not affected by aquifer horizontal anisotropy (the effective conductivity in the radial direction is estimated). Horizontal anisotropy was not detected in the one multiple-well test (at EW1), likely because of the proximity and number of the test wells, and because of aquifer heterogeneity. The deposits are expected to exhibit horizontal anisotropy of varying orientation throughout the model domain and horizontal anisotropy will be considered in future numerical model revisions; however, designing aquifer tests to estimate the horizontal anisotropy on OU2's scale is not practical.
10	Figure 4-7, Section B-B' shows that the plume is staying centered in the section, without any tendency to slide west, down section, as if it were being held there by a permeability contrast. This suggests that B-B' is actually a cross section of a fan, and the plume is embedded in coarse material along its axis, and is kept there by low-permeability deposits in the interfan low-energy zones. It also suggests that the lower plume shown in C-C' on Fig. 4-7 is not hydrodynamically trapped against the anticline, (which would produce an upward gradient at MW-25-C) but is in a deeper part of the alluvial fan, and may be migrating downwards, based on the downward gradient. The idea that the anticline controls groundwater flow is not supported by the head data.	The regional groundwater flow direction in the OU2 area is to the south which would limit "any tendency (*of the plume*) to slide west." The contamination found at MW23C may be laterally limited, but it may also extend to production well 2S/11W-30R3. It will be addressed under an upcoming Feasibility Study. A discussion will be added to Sections 5 and 6. If the extent of the contamination is indeed limited to the northwest, it may be either because of a permeability contrast or due to prevailing southwestern flow direction and limited dispersion. The groundwater flow direction in this deeper zone is not known with certainty; the production well is active and its pumping influence may extend to this area. The PCE concentrations in the aquifer zone at the top of the production well are about 5 ug/L indicating that if this contamination extends from MW23C, the production well is at the margin of the deeper plume. The anticline is thought to affect groundwater flow for the following reasons: 1) The groundwater flow direction turns from the southwest to south-southeast around the anticline axis which plunges to the northwest (Section 4.5.2.4). 2) The VOC plume extends along the inferred groundwater flow direction (Section 5), confirming that the flow and transport pathway wraps around the crest of the anticline. 3) The shallow groundwater flow gradient steepens in the

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		northeastern limb of the anticline as saturated thickness of the shallow aquifer units decreases and groundwater flows across the units (in the direction of lower permeability). The gradient then flattens as the flow enters the southern limb of the fold and groundwater flows again sub-parallel to the lithologic units (Section 4.5.2.6, p. 4-11). However, the anticline is not the only or main feature affecting groundwater flow at OU2. Recharge to spreading basins along the San Gabriel River and production pumping dominate the groundwater flow in the basin. Mountain-front recharge along the northeastern margin of the basin, and the sand channels in the alluvial fan complex also control the groundwater flow at OU2. The anticline likely has only a local effect on the groundwater flow conditions.
11	Cross Sections. The cross section numbers need to be added to the index map. The orientation of the sections makes it particularly difficult to determine the orientation of B-B'.	The cross-section names (e.g., B-B') will be added to the maps on figures 4-6 and 4-7. The ends of the cross-sections will be marked "northwest," etc., as appropriate.
12	Bubble map. The concentration ratios should have been molar concentrations, not weight, since all the compounds have different molecular weights. Comparing weights distorts the relationships among compounds that have degradation products, since all degradation products are lighter than the parent compounds. Groundwater contours should be added to the map.	Presenting the ratios of molar concentrations would be more appropriate if the map were used for estimating degradation rates of VOCs. However, the map (Figure 5-15) is not used for estimating degradation rates but is used to present the relative plume composition across OU2, with a special objective to show the chemical signature of different sources of contamination (e.g., CENCO refinery, McKesson Chemical, etc.). The ratios of concentrations in the units used (any units) are adequate for this purpose. Groundwater contours will be added to the map.
13	The model used was based on a previous model by the USGS. Any user of the model inherits its assumptions and flaws as well as its strengths. It is particularly important to make sure the old model's depiction of boundaries does not unintentionally conflict with the needs of the new model. Boundaries are generally set away from the area of interest of the model, and there is often less care and attention to the fine details, because small errors at the edges will usually not propagate into the deep interior of the model. But for a site of interest near the perimeter, these	The Omega model was based on the previous USGS model of the entire basin and covers only part of the USGS model domain. The Omega model boundaries were selected based on the physical settings and the groundwater flow conditions in the basin. The northeastern boundary of the Omega model is a physical boundary along the Puente Hills; it was implemented as a no-flow boundary in the model because it represents the limit of the alluvial deposits. The boundary will be revised to more closely follow the

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	simplifications may have large, sometimes adverse, effects. The user of the model is responsible for fixing these problems. It is not sufficient to assume that a model designed and accepted for another purpose will likewise be suitable for other purposes.	physical boundary of the basin. The southwestern boundary is the Newport-Inglewood fault zone which was modeled as an internal general-head boundary in the USGS model; it was assigned as a flux boundary in the Omega model with the transient flux computed by the USGS model. Note that this boundary is nearly impermeable (the flow across it is a small fraction of the total volumetric budget). There are no natural boundaries to the southeast and northwest; to limit the extent of the Omega model, these boundaries were selected along flowlines to represent nearly no-flow boundaries. The two boundaries were simulated as specified head boundaries; they are located sufficiently far away from OU2. With the exception of the western boundary segment near the Rio Hondo and San Gabriel River spreading basins, there is little water exchange across these model boundaries as confirmed by budget analysis.
14	The model was calibrated to heads, not flows. The previous flows were accepted without question. While models can generally calibrate to heads within acceptable levels, such solutions are non-unique and depend heavily on the accuracy of the water balance to generate flows, which then are distributed by the conductance fields. In the case of this model, heads are the most accurately known parameter, and flows are one of the most uncertain, yet without knowing flows, there is no way to know what K-field is correct, since an infinite number of Ks will calibrate to the same set of heads. Calibration to heads will not ensure that the model accurately matches the flow system. Some effort must be made to also calibrate to flows in order to reduce uncertainty.	The Omega model was calibrated to observed water levels. The flow components were used as model input, not output; as such, the model was not calibrated to the flow components. There are uncertainties in the magnitude of all of these flow components, including groundwater production rates. The uncertainties were addressed through model sensitivity analyses. No flow data suitable for use as a calibration data set were available. However, the flow into and out of the model was prescribed on input so the calibration to heads was constrained by the specified flow through the model. The specified head boundaries were placed along flowlines to limit the flow across them (Please see our response to Comment 13). The clarification of April 2, 2008 requested that DTSC identify the flows to be used in calibration.
15	The calibration figures show that there is considerable scatter in the calculated heads for the regional wells. While the mean error was within 10 percent, the standard deviation was notably high. It is likely that this is because of poor boundary flow conceptualization, specifically, the use of constant head nodes along the River which is not fully penetrating and constantly saturated.	This is a misunderstanding; the San Gabriel River was not used as a model boundary. The model boundary was selected in a way to minimize the groundwater exchange across the boundary, i.e., parallel to the groundwater flow direction. The budget analysis also indicated that there is little water exchange through the specified head boundaries, with the exception of the boundary segment near the spreading basins where a portion of the recharged water flows

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	Tabulation of the model water budget by zone and boundary type would be very useful to assess the proportion of model flows. In general, subsurface inflow and outflow ought not exceed areal recharge, and certainly not by orders of magnitude.	out of the model domain. This is expected to be the actual condition. The model volumetric budget showing breakdown by boundaries will be included in the report.
16	Areal recharge. Areal recharge is generally a very sensitive parameter, yet areal recharge was simply scaled and clipped for the model. There is known nonlinearity between rainfall and groundwater recharge, with practically no recharge when rainfall is less than 12"/yr, and nearly 30% when rainfall is greater than 20"/year. While the USGS capping of recharge at 1.3 inches (10% of an average year's rain) may be appropriate in some instances, there is no justification for this assumption at this area, and in fact this appears to underestimate recharge for wet years. The topo map also shows locations where there may be more or less surface recharge, and these could be easily incorporated into the model.	We concur that areal recharge is in general an important recharge component for shallow groundwater. However, areal recharge is a small component for the Omega model: the estimated areal recharge is only about 12% of the recharge through the spreading basins. In addition, inspection of the long term water level variations did not reveal any significant seasonal patterns. As such, we think the approach taken for the implementation of the areal recharge is appropriate for the purpose of the modeling. The distributed areal recharge is not capped at 1.3"/yr in the USGS (and Omega) model; the number 1.3 is the maximum normalized precipitation factor (determined by USGS for 1970-1971 and used to compute the infiltration rate from precipitation records).
17	In the case of this model, there are problems with the location and magnitude of recharge and the flow at boundaries. In the Omega area, Turnbull Canyon and other canyons are point inflow sources, as shown on the groundwater contour maps. The problem with assigning uniform mountain-front recharge is that it automatically introduces uncertainty in Ks, because it will certainly be too high in some places and too low in others. Inspection of the USGS topo map shows several specific places at canyon mouths where recharge may be adjusted, which will reduce uncertainty in K.	The areas upgradient of the Omega property supply a small amount of water to the downgradient area through mountain front recharges along the Puente Hills. The model boundary along Puente Hills will be revised to more closely follow the edge of the basin fill. The mountain-front recharge assigned along the boundary will be modified to represent its spatial distribution in more detail. It will be distributed along the model boundary according to watershed-area weighting for each canyon. This model revision will be an improvement but is not expected to decrease the uncertainties in the hydraulic conductivity distribution upgradient of the Omega property.
18	Another problem with recharge is how to handle the central basin pressure area recharge. The pressure area is, by definition, confined, so areal recharge does not affect the water balance much in this area. Further justification of recharge in the pressure area is needed.	The shallow aquifer is unconfined throughout the model domain, only the deeper units are confined. Areal recharge is applied to the shallow aquifer only. We believe this conceptual model is appropriate. Note that the conceptualization is the same as in the USGS model. There is likely a bigger time lag in water level response to precipitation in the Central Basin Pressure area than in the

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		Montebello Forebay area. Because areal recharge is only a small fraction of the total recharges and water levels do not show seasonal variations suggest areal recharge has limited impact on the groundwater flow in the model domain.
19	Boundary conditions. The specified-head boundary along the San Gabriel River, northeast, and southeast boundaries are likely to greatly overestimate boundary flux. The San Gabriel River is not fully penetrating, and resembles more a head-dependent flux boundary than a constant-head boundary. The other boundaries do not communicate with bodies of water at all, and specified head is inappropriate for them. A water balance for the model boundaries is likely to indicate that unnaturally high conductances are needed to handle all the water that specified-head boundaries transmit. Most, if not all, boundaries should be changed to specified-flux.	Please see our response to Comments 13 and 15.
20	Specific yield. Rollin Eckis studied specific yield in Los Angeles Basin soils, and found that most soils with more than one sieve size of particle tended to have specific yields in the 10% range, with very few clean coarse sands in the 25% range. (Calif. Div. Water Resources Bull 45, p 91-246, 1934). For the most part, outside of the Montebello Forebay, the local alluvial soils are mixed sizes, somewhat decomposed, and are seldom clean enough to have specific yields greater than 15%. Figure K-12 shows many instances of mismatches to hydrographs that are likely a result of overestimation of specific yield. Decreasing storage/specific yield will increase the responsiveness of the aquifer to changes in flux. Specific yield is related to effective porosity, and similar considerations apply to both. The soils data obtained during the studies do not support a conclusion that the materials beneath the site can be represented by 'clean sand'.	According to Fetter (Fetter, 1994, *Applied Hydrogeology*, p. 91) and Domenico and Schwartz (Domenico and Schwartz, 1990, *Physical and Chemical Hydrogeology*, p. 118), aquifer materials such as sand typically have specific yield greater than 20%. When the sediments are composed of different sizes, the total porosity and therefore the specific yield will be smaller. Soils with specific yield smaller than 10% are typically considered to be aquitard materials such as silt and clay. It is not clear from the comment what soils (surface soils vs. aquifer materials) Rollin Eckis analyzed. The California Department of Water Resources Bulletin 118 (see attachment) also supports the use of specific yield values greater than 10%. The specific yield was estimated to be 18% for the Central Basin pressure area. The pumping tests conducted at Omega were not designed for the estimation of specific yield because that would require much longer pumping (and higher costs). Specific yield can be constrained to a fairly narrow range of values according to the character of the aquifer material (e.g., using the literature cited above). We will include sensitivity analysis of specific yield in the model section to show the potential impact of values assigned to this

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		parameter.
21	The mismatch in heads shown near Los Nietos Road, as mentioned above, could likely be fixed by increasing recharge coming down the Worsham fan.	The mountain-front recharge distribution will be modified (see the response to Comment 17).
22	Contaminant transport. Alluvial fans in semiarid settings similar to the site generally include periodic flood deposits with charcoal from brushfires. It is likely that the materials beneath the site include substantial organic carbon in the form of charcoal, concentrated in layers. In addition, organic carbon in the form of hydrocarbons is known to be found at various places beneath the site. The VOCs of interest at the site are variably adsorbed to organic carbon, resulting in variable retardation of the rate of plume migration for the different compounds. Of the VOCs, 1,4-dioxane is affected the least, and PCE the least. If retardation is to be neglected in the analysis, then a compound such as 1,4-dioxane should be used instead of TCE or PCE for calculation of groundwater velocities and plume velocities. Naturally occurring organic carbon has not been adequately characterized beneath the site.	We concur that sorption and de-sorption occurs during the transport of VOCs at OU2. However, there are multiple sources of VOCs throughout OU2, so a simple comparison of the transport of one sorbing and one non-sorbing compound cannot be made without accounting for all the sources (the mass released and the timing are not sufficiently known for every source). As shown by the plume maps, 1,4-Dioxane did not move as far as PCE even when compared along the pathway from the Omega property along the Angeles Chemical/McKEsson Chemical area which are sources of both contaminants. This seems to indicate that sorption is not a major process affecting VOC transport at OU2. Advection and hydrodynamic dispersion are thought to affect the transport of VOCs at OU2 to a much greater degree. The uncertainties in other transport parameters, such as effective porosity and dispersion coefficient, have greater impacts on the transport model results than sorption. VOCs also adsorb to mineral surfaces, so some sorption is expected even if organic carbon content is low. For PCE, the threshold of organic carbon content is 0.0002 for surfaces of organic materials to be the primary sorption sites. However, sorption onto mineral surfaces is difficult to quantify (Fetter, 1992. *Contaminant Hydrogeology*). The remedial investigation at Omega OU1 (Final On-Site Soils Remedial Investigation Report, November 14, 2007) included the collection of 53 samples for the analysis for total organic carbon (TOC). The TOC ranged from 510 to 5300 milligrams per kilogram, with an average of 1693 and a median of 1600 mg/kg (corresponding to mass fractions ranging from 0.0005 to 0.005 with an average of 0.0016). TOC fractions in soil samples collected near the water table at the Oil Field Reclamation Project (OFRP) site ranged from 0.0003 to 0.0025 with an average of 0.001. Sorption will be included in any simulations that would predict the plume movement in the future. Transient concentration data will be

Comment #	Comments from DTSC	CH2M HILL Responses
		available from groundwater sampling at downgradient wells (CENCO-MW603, CENCO-MW605, MW27, MW29, and MW30) that detected the arrival of the plume edge. These data could be used for the estimation of the sorption coefficients.
23	The interpretation of the site stratigraphy is not supported by the plume geometry, especially its relation to topography, and by the vertical gradient data. The conceptual hydrogeologic model should be reevaluated. While a thin section of San Pedro formation may be present at depth beneath the upper part of the Unit 2 area, most of the section appears to consist of continental alluvial fan deposits which originate on and lap onto the Repetto Hills. While the alluvial fan units are time-correlative with Gaspur-age deposits in Whittier Narrows, they are not the same facies, and do not have the same hydraulic properties.	There are no significant differences in the interpretation of the stratigraphy at OU2 by DTSC and CH2M HILL. Please see the responses to Comments 1, 2, 3, 6, and 7. San Pedro formation is present at OU2 (see Bulletin 104); its exact depth was not determined from the investigation results but it is likely below the extent of the contamination. The identification of the San Pedro formation is not the focus of the report. Please see our response to Comment 6 regarding the Repetto Hills. Please see our response to Comment 1 regarding Gaspur aquifer.
24	The groundwater model relies heavily on an earlier model, and has questionable boundary conditions at its lower extent. As a result, there is considerable uncertainty in the results, which could be reduced by further constraining flows at the boundaries. Likewise, recharge has been applied with a broad brush, but there are obvious ways to refine recharge in the area near the site that might improve the model. A groundwater budget for the model that compares boundary inflows by category, pumpage, recharge, and outflow by category, is needed. Changing constant-head (CHB) boundaries to general head (GHB) boundaries would help limit water balance errors, which drive conductance errors. If recharge and discharge from constant-head nodes significantly exceeds areal recharge and mountain-front recharge, then these terms have likely been overestimated, and therefore hydraulic conductivity in the lower model area is overestimated.	Please see the responses to the Comments 13, 14, 15, 16, 17, 18 regarding model boundaries and implementation of flow components.
25	Vertical gradients have not been addressed. The pattern of vertical head distribution suggests there may be data gaps in the lower part of the plume.	Vertical head separations at OU2 were taken into consideration during the development of the conceptual model and the implementation of the numerical model. Additional wells with multiple screens were installed after 2006; data from these wells were not available for the modeling but will be used in future model

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		revisions. Please see our response to Comments 8 and 10 about the deeper zone contamination.
26	Quantitative velocities calculated by the model should not be relied on until additional work is done to calibrate flows.	The velocities calculated by the model can simply be compared to the velocities calculated from the documented migration of the plumes. Please see our response to Comment 14 about the calibration to flows.